POINT OF VIEW

A new difficult airway management algorithm based upon the El Ganzouri Risk Index and GlideScope® videolaryngoscope. A new look for intubation?

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ABSTRACT

Background. An El Ganzouri risk index test (EGRI) score of seven and the ability to achieve difficult laryngeal exposure with the GlideScope® may represent a highly predictive decisional threshold. Hence, we hypothesized that a new difficult airways algorithm that is EGRI- and GlideScope®-based may enable tracheal intubation in every patient.

Methods. Thirteen staff practitioners trained in videolaryngoscopic intubation followed the algorithm from 2008 through 2010. Elective and emergency neurosurgical patients assessed as having an EGRI score of seven and higher underwent flexible fiberoptic bronchoscopy (FFB) intubation while conscious. Those with a score of six and lower were intubated with the GlideScope®, excluding patients with morbid obesity or pharyngo-laryngeal or neck tumors. A decision to perform alternative procedures, difficult laryngeal exposure [Cormack and Lehane (CL) grades III-IV], difficult ventilation and failure to intubate were recorded.

Results. The decisional rule was applied in 6,276 patients and resulted in six FFB intubations in conscious patients. The overall incidence of CL grade III-IV views was 0.2%. Difficult videolaryngoscopy was found in 14 patients (0.14%) with a score of 6 and lower. *Post-hoc* examinations of FFB intubations revealed five difficult laryngeal exposures. The positive predictive value was 85.7%, while the negative predictive value was 99.9%. The incidence of difficult ventilation and difficult laryngeal exposure was 0.03%. Two patients with neck tumors were assigned to alternative procedures.

Conclusion. Adherence to the decisional process of the algorithm and to GlideScope® videolaryngoscopy achieved successful tracheal intubation in our cohort of patients. *(Minerva Anestesiol 2011;77:1011-7)*

Key words: Airway remodeling – Laryngoscopes - Intubation.

In the last fifteen years, expert committees and scientific societies have elaborated guidelines and algorithms to best manage the failure of Macintosh direct laryngoscopy [1-3] and to allow for successful intubation of most patients with difficult airways. The prediction of difficult airways and the device to be used as an alternative to the Macintosh blade are the critical issues of the difficult airway algorithms. This paper describes the current status in predicting difficult airways and the related role of rigid videolaryngoscopy in comparison to direct laryngoscopy. In the section on rationale, the methods and impact of a new difficult airway algorithm based upon GlideScope® videolaryngoscope combined with the El-Ganzouri simplified risk index (EGRI)[4] will be discussed.

Current status in the prediction of the difficult airway

In the last two decades, a considerable number of anthropometric parameters associ-

ated with difficult intubation have been identified and measured. In most of the studies, their predictive value was obtained with respect to a primary outcome, usually defined as difficult or easy airway exposure and categorized according to standardized Cormack and Leahne (CL) grades (grades I-II for easy and III-IV for difficult).[5] Difficult airways exposure is considered the definitive condition predisposing to difficulty introducing the tube into the larynx and, hence, failed intubation. In the overall patient population, the reported rate for difficult laryngeal exposure with a Macintosh blade was 5.8% (95% CI, 4.5%-7.5%).[6] The ideal model for the prediction of difficult laryngeal exposure should have perfect sensitivity and specificity, resulting in accuracy greater than 90%. The authors tried to find predictive thresholds with the highest sensitivity, but such thresholds were always associated with a reduced specificity.[7] Threshold values characterized by a high rate of false-positive results may complicate decision making toward truly safe alternative procedures.

In our opinion, the current status of the prediction of difficult airways may be modified to reduce the prevalence of the outcome considered (*i.e.*, difficult laryngeal exposure), thus minimizing the overall impact of unpredicted difficulties and adopting a high threshold value with a low number of false-positive results.

Videolaryngoscopy in the management of difficult intubation

Rigid videolaryngoscopes are emerging among the devices suggested as alternatives to direct laryngoscopy.[8] Videolaryngoscopes allow for a better visualization of the larynx, compared with direct laryngoscopy, in intubation that are anticipated to be difficult (CL I-II 90.2% *vs.* 60.4%).[9] The prevalence of difficult laryngeal exposure may be reduced to 1% with the GlideScope® and to 3.2% with the Macintosh video laryngoscope (V-MAC®) in an unselected patient population.[10, 11] Aziz MF *et al.* showed that the GlideScope® rescued 224 of 239 (94%) failed direct laryngoscopies [12], and Amathieu *et al.* successfully intubated 24 of 29 failed intubations with the Airtraq® optical laryngoscope.[13] This means that, when direct laryngoscopy, after one or more attempts, leaves only the possibility of a blind intubation, one may regain visual control with videolaryngoscopy. Visual control may facilitate tracheal intubation. To achieve this, the videolaryngoscope should project a large, magnified and stable visual field of the laryngeal structures on a monitor of sufficient size. The videolaryngoscope blade should move the eye along the primary curve and provide a line of sight through the laryngeal vestibule to the glottis, displace the tongue and allow for easy movement of a preformed tube. In our opinion, among the available devices, these characteristics are best guaranteed by the angulated blade of the GlideScope®.

The ease with which proper use of the device can be learned is considered to be another important requirement. Most videolaryngoscopes have a shorter learning curve than does the Macintosh blade for inexperienced users.[8] However, this ease of use may not ensure full success when videolaryngoscopes replace direct laryngoscopy in difficult cases. Recently, Aziz *et al.* demonstrated, in the two institutions involved in their study, that the GlideScope® was used more frequently at the institution where the failure rate was significantly lower. At this institution, 51 health care providers performed a mean of 21.7 GlideScope® intubations, whereas at the other institution, 91 health care providers performed 9.9 intubations. In the study, both experts and non-experts had an overall 0.3% major complication rate, including dental, pharyngeal or laryngo-tracheal injuries.[12]

These data support our opinion that, after at least 20 intubation, or preferably with routine use, the difficulties in endotracheal insertion of the GlideScope® [14] may improve, and the complications will decrease.

Videolaryngoscopy and prediction of difficult airways

The predictive index tests currently used for the Macintosh blade have been reclassified for videolaryngoscopic intubation. In the literature, the revaluations regarding the currently used predictive tests refer to the GlideScope®. Tremblay *et al.*

correlated the following variables with difficult GlideScope® intubation in 400 patients: a high upper lip bite test score, CL grade and thyromental (TM) distance.[15] Between these variables, the CL grade reached the maximum accuracy value of 68%. Aziz *et al.* identified the presence of airway pathology from previous surgery, a local massor radiation as the strongest predictors of failed Glidescope® intubation in 2004 patients.[12] The accuracy of the predictors studied by the author was 73%. In our institution, the El-Ganzouri risk index (EGRI) [16], with respect to the outcome of laryngeal exposure combined with GlideScope® intubation, was studied in a sample of 843 patients, compared with 994 patients intubated with direct laryngoscopy.[17] The resulted accuracy of EGRI improved significantly from 74% to 91%. This best performance of EGRI was considered to be a consequence of the lower rate of difficult laryngeal exposure with the GlideScope®, compared with the Macintosh blade (1.6% *vs.* 5.6%). In this study, an EGRI score of 7 was associated with a PPV (positive predictive value) of 85% and a NPV (negative predictive value) of 98.3%.

A new difficult airway management algorithm

The significant accuracy of the EGRI (91%) with respect to difficult laryngeal exposure and the resulting highly predictive score of 7 for adopting the GlideScope® may introduce, in our opinion, a new paradigm for assembling a difficult airway management algorithm. From the dichotomous branches derived from the value of seven, two different decisional paths may be drawn, both reaching the final common path of the patient being intubated and ventilated. The first path allows for standard GlideScope® intubation in the patient that is sedated and paralyzed; the second allows for FFB intubation while the patient is conscious. An institutional decision-making algorithm was consequently developed and assessed at our institution (Figure 1).

We hypothesized that the adoption of the algorithm may confirm the low rate of difficult laryngeal exposures associated with GlideScope® intubation and the low rate of false-positive results associated with the predictive rule of an EGRI score of 7, enabling tracheal intubation to be performed for every patient that requires it.

Methods

Thirteen staff practitioners of the Neurologic Institute Carlo Besta followed the algorithm from 2008 through 2010. They routinely used the GlideScope® for at least one year. Two new practitioners performed 50 GlideScope® intubations under supervision.

Patients scheduled for elective or emergency neurosurgical procedures who were older than 16 years and undergoing general anesthesia requiring tracheal intubation were assessed with the EGRI score (minimum score 0-maximum 12; see notes Figure 1). Patients with morbid obesity (BMI >30 kg/m^2), with pharyngo-laryngeal or neck tumors and with large scars were assessed for the anatomical feasibility of bag mask ventilation and laryngoscopy. These patients, even with an EGRI lower than 7, could be directed toward fibroscopic intubation or conscious tracheotomy and were excluded from the algorithm. All patients with a score of 6 and lower underwent general anesthesia, were paralyzed and were intubated. In cases of scores of 6, agreement in scoring between the raters was always checked. If the agreement was less than 90%, resulting in the possibility of a score of 7, patients were sedated and their laryngeal structures were exposed with quick look GlideScope® laryngoscopy. In cases of CL grade III-IV and difficult bag mask ventilation, patients were awakened and intubated with FFB.

The degree of laryngeal exposure was scored with a GlideScope® according to the CL grading system. A graphical representation, similar to that introduced by Samsoon and Young [17], was printed on the anesthesiological record for guidance. Anesthesiologists were also invited to define grades II in IIa and IIb according to the Yentis classification.[18]

After determining the CL grade, the external laryngeal displacement (ELD) maneuver or reintroduction of the blade was performed when laryngeal exposure was judged to be unsatisfactory. In using a malleable stylet, the most dis-

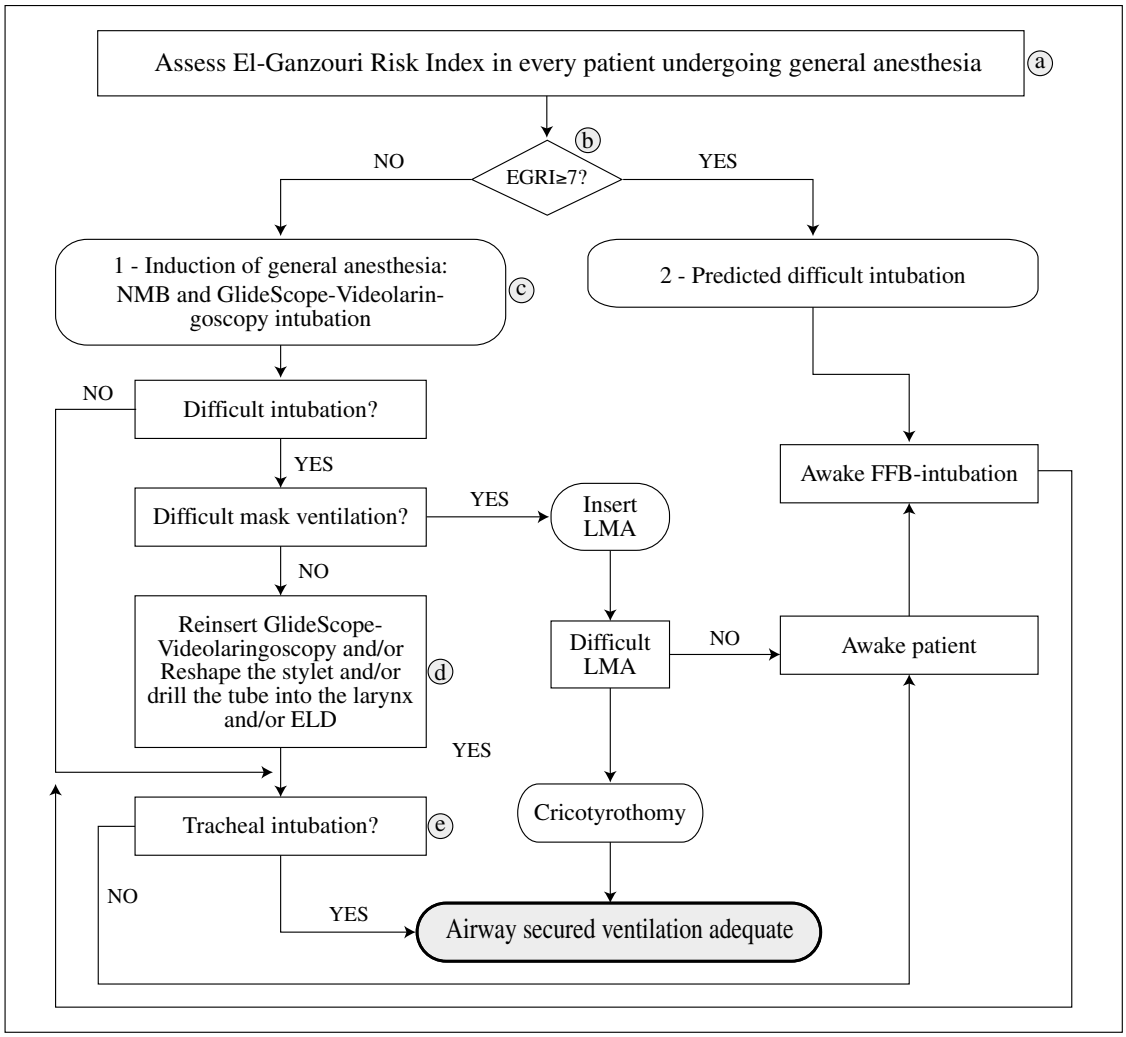

Figure 1.—Difficult airway management algorithm. [a]Patients with morbid obesity and pharyngo-laryngeal or neck tumors should be assessed for anatomical feasibility of bag mask ventilation and laryngoscopy. If the EGRI is lower than 7, you may consider flexible fiberoptic broncoscopy (FFB) intubation or tracheotomy performed while the patient is conscious. [b]EGRI score ranges 0 to 12. Variables are mouth opening (<4, ≥4 cm; score 1, 0), thyromental distance (>6.5, 6-6.5, <6 cm; score 0, 1, 2), modified Mallampati class (I, II, III and IV; score 0, 1, 2), neck movement (>90°, 80°-90°, <80°; score 0, 1, 2), ability to prognath (yes, no; score 0, 1), body weight (<90, 90-110, >110 kg; score 0, 1, 2), and history of difficult intubation (none, questionable, definite; score 0, 1, 2). When there is no agreement between the score of 6 and 7, a "quick look" should be performed. [c]NMB: neuromuscular blockade. [d]ELD: external laryngeal displacement. [e] If difficult ventilation occurs anytime during intubation attempts, insert an LMA.

tal part of the endotracheal tube was routinely bent into a "hockey stick" shape.[19] In cases of difficult intubation, the angle and the length of the distal portion of the tube was changed. CL scores of I-II were considered easy videolaryngeal exposures, whereas scores of III-IV were considered difficult. Failed intubation was defined as the inability to intubate the patient using the GlideScope® technique despite three attempts at laryngoscopy and/or intubation. In cases of failed intubation, anesthetics were suspended, curarization was reversed and the patient was ventilated by means of bag mask or laryngeal mask until spontaneous breathing resumed. Then FFB intubation in the conscious patient was performed. In cases of intubation with FFB in the conscious patient, CL grades were evaluated with the tracheal tube in situ by

means of GlideScope® videolaryngoscopy. Full visualization of all the hypopharyngeal and laryngeal structures was considered grade I-II. The intubating anesthetists were aware of the preoperative assessment to support their own decision to perform direct laryngoscopy or an alternative technique. A second anesthesiologist who was blinded to the EGRI evaluated the CL grade on the video screen and judged ease or difficulty of intubation and adequacy of mask ventilation. Ease or difficulty of mask ventilation was judged with a four-point scale [20] ranging from grade 1 to 4: grade 1 - ventilated by mask; grade 2 - ventilated by mask with oral airway/adjuvant with or without muscle relaxant; grade 3 - difficult ventilation (inadequate, unstable, or requiring two providers) with or without muscle relaxants; and grade 4 - unable to mask ventilate with or without muscle relaxants. When difficult ventilation (grade IV) occurred and/or pulsed arterial oxygen saturation (SpO_2) decreased to less than 90% at any time during attempts at laryngoscopy or intubation, an LMA was inserted, and the patient was awakened and intubated with FFB. If LMA ventilation failed, as indicated by no end-tidal carbon dioxide or chest wall movement within 30 s after laryngeal mask placement, percutaneous tracheotomy was performed.

Intubation with the GlideScope® was attempted by the attending anesthesiologist or by the resident under supervision. The decision to perform an alternative procedure in cases of predicted difficult intubation or to awaken the patient in cases of difficult or failed intubation was made by the attending anesthesiologist. All of the data were collected using standardized picklist choices in the anesthesia record with the option of free text entry if the choices did not offer the anesthesiologist the ability to fully document the clinical observation. Incomplete data were excluded from the retrospective analysis.

The primary outcome included routinely used measures of GlideScope® videolaryngoscopy, consisting of the number of cases, rates of difficult laryngeal exposure and number of failed intubations.

The predictive rule based on the threshold of seven was validated by measuring the positive predictive value (PPV) and the negative predictive value (NPV). The PPV is the number of patients predicted to have difficult airways who subsequently proved to have difficult laryngeal visualization divided by the total number of patients predicted to have difficult airways. The NPV is the number of patients predicted not to have a difficult airway who subsequently proved not to have difficult laryngeal visualization divided by the total number of patients predicted not to have difficult airways.

Impact analysis of the predictive rule (used to make decisions) was evaluated by measuring the safety and efficiency. Safety was defined as the proportion of all patients experiencing the predicted outcome (CL III-IV) who receive FFB intubation, and efficiency was defined as the proportion of all patients not experiencing (CL I-II) the predicted outcome who did not receive the targeted intervention. Safety and efficiency are synonymous with sensitivity and specificity only when clinicians apply the decision rule logic in exactly the same way in all patients.[21]

The measured secondary outcomes were ease (grade I-II) or difficulty of mask ventilation (grade III-IV) and when the LMA was used.

Results

From January 2008 to December 2010, data were collected on 6,278 patients undergoing general anesthesia. Outcome data (laryngeal view or difficult ventilation grade) were unavailable in 49 instances (0.8%), and these data were not included in the analysis. As shown in Table I, the decision rule (EGRI score of 7) was applied in 6,276 cases resulting in 6 successful FFB intubations in conscious patients. In 2 patients with a score lower than 7, the decision rule was not applied because the patients had neck tumors. FFB intubation was planned for one patient, and conscious tracheotomy was planned for the other one. GlideScope® videolaryngoscopy resulted in difficult laryngeal exposure in 14 patients (0.2%). Of these, 5 CL *post-hoc* grade III-IV views were found among the 6 FFB intubations, whereas 9 CL grade III views occurred in the 6,270 patients with unpredicted difficult airways (0.14%). In this group of 6,270 patients,

Table I.—*Outcome of airway management of all anesthetized participants using the new algorithm.*

Outcome	N. (%)
All partecipants (N. = 6278)	
Planned FFB intubation	1 (.02)
Planned tracheotomy	1 (.02)
Patients evaluated with EGRI[a] (N. = 6276)	
Sedated and paralyzed (score <7)	6 270
FFB[b] intubations (score ≥7)	6
Difficulties:	
CL grade III unpredicted	9 (0.14)
CL grade III to II with ELD[c]	29 (0.46)
CL grade IIb	17 (0.27)
CL grade III-IV in FFB intubations	5 (0.07)
Difficult ventilation and CL grade I-II	61 (1.0)
Difficult ventilation and CL grade >II	2 (0.03)

[a]EGRI: el-Ganzouri risk index; [b]FFB: flexible fiberoptic broncoscopy; [c]ELD: external laryngeal displacement.

grade IV views were never found, and they were all intubated without any harm. In the same group, less difficult laryngeal exposures, consisting both of modified CL IIb and CL III views (0.26% and 0.42%, respectively) converted to grade II with ELD. One patient rated 6, without agreement between 6 and 7, underwent a "quick look" laryngoscopy without muscle paralysis. The grade of laryngeal exposure was IV, and bag-mask ventilation was difficult (grade IV). The patient spontaneously recovered breathing before insertion of the LMA. He was then awakened and successfully intubated with FFB.

The prediction rule derived from these results has been validated, resulting in a PPV of 85.7% and a NPV of 99.9%. The clinical impact of the decisional rule has been defined by safety of 35.7% and efficiency of 99.8%.

Difficult ventilation occurred in 63 (1.03%) patients. Only one patient was not able to be ventilated (grade IV). There were two (0.035) CL III-IV views associated with difficult ventilation. An LMA was never used.

Clinical impact of the algorithm

Data retrospectively collected after three years of application of the algorithm showed a very low rate of difficult laryngeal exposure (0.2%). The high predictive value of the threshold adopted in our cohort of patient increased the probability of difficult laryngeal exposure from 0.2% to 85%. The probability of CL III-IV after a negative EGRI score was 0.14%; therefore, the negative examination decreased the probability of CL III-IV from 0.22% to a very low level of 0.14%. The high efficiency value (99.8%) was due to the low rate (1 out of 6) of easy laryngeal exposures in patients undergoing broncoscopy when the score was 7 and higher. The safety of the decisional rule was low because only 35% of difficult exposures were converted to FFB intubations. In our setting, both the nine patients with false-negative results and the other 46 patients with less difficult laryngeal exposure (CL IIb, CL III to CL II after ELD) were all successfully intubated. The success rate of 100% in our setting was higher than that reported in another large series (97%).[12] This published success rate was due to a broad sample of providers that selected most patients with predicted difficult airways for GlideScope® intubation. In our setting, GlideScope® intubations were routinely performed by experts in a population undergoing general anesthesia with a reduced probability of difficulty. The reduction was due to the threshold of seven, which discloses multiple severe deviations from the norm of relevant anthropometric parameters associated with difficult intubation and difficult mask ventilation, and was due to the exclusion criteria, such as severe neck pathology, which are considered strong predictors of failed Glidescope® intubation.[12] Similarly, difficult-to-intubate and difficult-to-ventilate scenarios were reduced to only two patients (0.03%), a value ten times lower than that reported with Macintosh laryngoscopy (0.37%).[20]

The interpretation of such results must take one weakness into account. The patient population was limited to only neurosurgical procedures, only four operating rooms, and only 13 staff anesthesiologists. Further studies are needed to validate the decisional rule in broader settings and to compare the GlideScope® with other rigid videolaryngoscopes.

Conclusions

The EGRI predictive test may acquire good accuracy when videolaryngoscopy improves vis-

ualization of laryngeal structures in comparison to direct laryngoscopy. In our experience, the application of an algorithm based on the decision rule derived by an EGRI of 7 for every patient undergoing general anesthesia and routinely intubated with GlideScope® reduces the risk of difficult and failed intubation.

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